Particulate Matter (PM), $PM_{2.5}$, Nitrogen Oxides, Carbon Monoxide, Metals, Polynuclear Aromatic Hydrocarbons, and Formaldehyde Boiler Source Test Report

Bitter Root RC&D Area, Inc.
Council, Idaho School
Fuels for Schools Project

Test Date: March 27, 28, and 29, 2007
Aspen File: BRT07021

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EXECUTIVE SUMMARY

Aspen Consulting & Testing, Inc. (Aspen) was retained by Bitter Root RC&D Area, Inc. (Bitter Root RC&D) to conduct emissions testing at the Council, Idaho School wood-fired boiler located in Council, Idaho. Aspen performed emissions testing consisting of particulate matter (PM), PM with an aerodynamic diameter of up to 2.5 micrometers ($PM_{2.5}$), nitrogen oxides (NO_x), carbon monoxide (CO), select metals (arsenic, cadmium, chromium, and nickel), polynuclear aromatic hydrocarbons (PAH), and formaldehyde tests on the Council School wood fired 1.875 million British thermal units (mmBtu) Messersmith built Hurst boiler emissions stack.

The purpose of the source testing was to determine PM, $PM_{2.5}$, NO_x, CO, metals, PAH, and formaldehyde emissions rates at both high fire and normal fire conditions. The data collected on the wood-fired boiler performance will provide useful information to the Fuels for Schools program in considering future potential conversions of other heating systems to forest biomass fuel.

High fire condition means the boiler was tested during peak load (100 percent load). Normal fire condition means the boiler was tested during normal heating demands for the current weather. During normal fire condition the load of the boiler varied throughout the testing.

Table ES-1 below is a summary of the PM, $PM_{2.5}$, NO_x, CO, metals, PAH, and formaldehyde emissions test results for the wood-fired boiler at both high fire and normal fire conditions. Specific metals tested were arsenic, cadmium, chromium, and nickel. Specific PAH analytes were acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(e)pyrene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, flourene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene. Table ES-1 only contains PAH data that recorded a reading from the laboratory analysis. PAH values of zero are not reported in the table below.

TABLE ES-1
SUMMARY OF BOILER EMISSION RESULTS
COUNCIL, IDAHO SCHOOL
MARCH 27, 28, AND 29, 2007

Pollutant	Units	High Fire	Normal Fire
Particulate Matter	lb/hr	1.194	0.921
	lb/mmBtu	0.442	0.570
Particulate Matter under 2.5 microns	lb/hr	0.338	0.529
	lb/mmBtu	0.129	0.228
Nitrogen Oxides	lb/hr	1.01	0.41
	lb/mmBtu	0.41	0.22
Carbon Monoxide	lb/hr	0.11	0.09
	lb/mmBtu	0.04	0.05
Metal - Arsenic	lb/hr	1.58e-5	3.20e-6
	lb/mmBtu	6.42e-6	2.65e-6
Metal - Cadmium	lb/hr	8.66e-5	1.76e-5
	lb/mmBtu	3.52e-5	7.87e-6
Metal - Chromium	lb/hr	9.79e-5	1.57e-5
	lb/mmBtu	3.98e-5	7.03e-6
Metal - Nickel	lb/hr	8.98e-5	1.66e-5
	lb/mmBtu	3.65e-5	7.54e-6
PAH – Benzo(ghi)perylene	lb/hr	1.24e-6	0
	lb/mmBtu	5.04e-7	0
PAH – Fluoranthene	lb/hr	6.43e-6	4.40e-6
	lb/mmBtu	2.62e-6	2.86e-6
PAH – Naphthalene	lb/hr	9.35e-6	1.18e-5
	lb/mmBtu	3.80e-6	9.30e-6
PAH – Phenanthrene	lb/hr	5.97e-6	6.21e-6
	lb/mmBtu	2.43e-6	3.91e-6
PAH – Pyrene	lb/hr	7.35e-6	8.03e-6
	lb/mmBtu	2.99e-6	6.39e-6
Formaldehyde	lb/hr	0.0023	0.0023
	lb/mmBtu	0.0009	0.0010

Notes:
PAH Polynuclear Aromatic Hydrocarbons
lb/mmBtu Pounds of Pollutant per Million British Thermal Units
lb/hr Pounds of Pollutant per Hour

1.0 INTRODUCTION

Aspen Consulting & Testing, Inc. (Aspen) was retained by Bitter Root RC&D Area, Inc. (Bitter Root RC&D) to conduct emissions testing at the Council, Idaho School wood-fired boiler located in Council, Idaho. Aspen performed emissions testing consisting of particulate matter (PM), PM with an aerodynamic diameter of up to 2.5 micrometers ($PM_{2.5}$), nitrogen oxides (NO_x), carbon monoxide (CO), select metals (arsenic, cadmium, chromium, and nickel), polynuclear aromatic hydrocarbons (PAH), and formaldehyde tests on the Council School wood fired 1.875 million British thermal units (mmBtu) Messersmith boiler emissions stack.

The purpose of the source testing was to determine PM, $PM_{2.5}$, NO_x, CO, metals, PAH, and formaldehyde emissions rates at both high fire and normal fire conditions. The data collected on the wood-fired boiler performance will provide useful information to the Fuels for Schools program in considering future potential conversions of other heating systems to forest biomass fuel.

High fire conditions means the boiler was tested during peak load (100 percent load). Normal fire condition means the boiler was tested during normal heating demands for the current weather. During normal fire condition the load of the boiler varied throughout the testing.

Results of the emissions tests at the Council, Idaho School wood-fired boiler are presented in Section 3.0. Appendix A contains correspondences between Aspen, Bitter Root RC&D, and the Idaho Department of Environmental Quality.

2.0 FACILITY AND EMISSION SOURCE OPERATION

The Council, Idaho School facility consists of four buildings that are heated by the wood-fired boiler. The four buildings consist of classrooms and gymnasiums for the high school, a separate building for the elementary school, a building for the high school shops, and the boiler building. Future buildings heated by the boiler may include a green house and office building across the street.

The wood-fired boiler is a Messersmith built Hurst boiler rated at 1.875 million British thermal units per hour (mmBtu/hr) output. The boiler is housed in a separate building on the school grounds and was designed by CTA Engineering. Also included in the boiler building is a backup natural gas fired boiler.

3.0 SUMMARY OF RESULTS

The following is a summary of the production data and emissions results obtained during the March 27, 28, and 29, 2007 test campaign conducted by Aspen.

3.1 PRODUCTION RATES

The Messersmith built Hurst boiler process data was recorded from the display panel every 30 minutes during the emissions testing campaign on March 27, 28, and 29, 2007. Three wood chip fuel samples were collected over the course of each day of testing. The fuel samples were sent to the Minnesota Valley Testing Laboratory for an ultimate analysis. Table 3-1 presents the results of the fuel ultimate analysis. Table 3-2 provides a complete account of the recorded process data and general test times of the pollutants tested.

The boiler heat input in mmBtu/hr was calculated by multiplying the average of three fuel samples analyzed for Btu content per day by the amount of fuel burned based on the recorded fuel rate. The fuel rate determined the boiler load that in turn determined the amount of wood fuel feed to the boiler at the different load conditions. For example, 100 percent load meant maximum wood chip fuel fed to the boiler, and 50 percent load meant half of the maximum wood chip fuel was fed to the boiler.

The fuel rate recorded 60 percent at high fire. The 60 percent value represented maximum or 100 percent load. The actual load per reading was calculated by taking the fuel rate value dividing by 60 and multiplying by 100 to give a boiler load percentage. The percent load was required to determine the amount of wood chip fuel fed to the boiler at lower load conditions. The amount of fuel burned at high fire or 100 percent load was determined by measuring the fuel feed auger rate. Two revolutions of the fuel feed auger took 80 seconds to complete. Two revolutions of the auger were measured to contain 10.9 pounds of wood chip fuel. Therefore, 60 percent fuel rate represented 100 percent boiler load which equaled 490.5 pounds of wood chips per hour. This value was calculated by the formula below.

$$\left(\frac{2\,revolutions}{80\sec}\right)\left(\frac{60\sec}{\min}\right)\left(\frac{60\min}{hour}\right)\left(\frac{10.9\,pounds}{2\,revolutions}\right) = 490.5\ pounds/hour$$

TABLE 3-1
ULTIMATE FUEL ANALYSIS
COUNCIL, IDAHO SCHOOL

Date	Run	Analyte Percent Weight							Calorie
		Total Moisture	Ash	Total Sulfur	Carbon	Hydrogen	Nitrogen	Oxygen	Btu/hr
3/27/07	1	34.25	6.28	0.02	30.81	7.46	0.20	55.23	5,483
	2	38.51	7.46	0.02	28.09	7.65	0.20	56.58	4,786
	3	40.85	4.41	0.02	28.21	7.92	<0.2	59.24	4,772
	Average	37.87	6.05	0.02	29.04	7.68	0.20	57.02	5,014
3/28/07	1	33.40	3.22	<0.01	32.68	7.62	<0.2	56.27	5,785
	2	28.97	2.85	<0.01	34.56	7.41	<0.2	54.97	6,104
	3	38.69	9.74	0.01	26.86	7.47	<0.2	55.72	4,649
	Average	33.69	5.27	0.01	31.37	7.50	<0.2	55.65	5,513
3/29/07	1	31.92	2.87	<0.01	33.40	7.62	<0.2	55.90	5,864
	2	28.41	3.56	<0.01	34.87	7.34	<0.2	54.02	6,118
	3	25.79	2.47	<0.01	36.57	7.18	<0.2	53.57	6,478
	Average	28.71	2.97	<0.01	34.95	7.38	<0.2	54.50	6,153

Notes:
Btu/hr British Thermal Units per Hour
< Less Than

Production data and fuel ultimate analysis is presented in Appendix B.

TABLE 3-2

BOILER PROCESS INFORMATION
COUNCIL, IDAHO SCHOOL

Date	Time	Fire Rate	Fuel Rate	Boiler Load	Boiler Temp	Damper	Overdraft	Fuel Sample Analyzed	Boiler Input	Notes
			%	%	Deg F	% open	%	Btu/lb	mmBtu/hr	
3/27/2007	10:30	High	60	100	189	30	70		2.46	Form R1 / PAH R1 / Metals R1
	11:00	High	60	100	185	30	70		2.46	NOx & CO R1
	11:30	High	60	100	185	30	70		2.46	Metals R2
	12:00	High	60	100	192	30	70	5483	2.46	Form R2
	12:30	High	60	100	185	30	70		2.46	PAH R2 / NOx & CO R2
	13:00	High	60	100	184	30	70		2.46	
	13:30	High	60	100	187	30	70	4786	2.46	Form R3 / Metals R3
	14:00	High	60	100	193	30	70		2.46	NOx & CO R3
	14:30	High	60	100	193	30	70		2.46	
	15:00	OFF								Boiler Shut Down for Cleaning
	16:25	High	60	100	171	30	70		2.46	PM2.5 R1 / PAH R3
	17:00	High	60	100	175	30	70	4772	2.46	
	17:25	High	60	100	181	30	70		2.46	Fuel feed rate measured
	17:55	High	60	100	189	30	70		2.46	
3/28/2007	8:30	Normal	41	68	167	16	36		1.85	PM R1/NOx&CO R4/PM2.5R4
	9:00	Normal	46	77	170	19	43	5785	2.07	
	9:30	Normal	46	77	170	19	43		2.07	
	10:00	Normal	59	98	164	29	68		2.66	NOx & CO R5
	10:30	Normal	59	98	164	29	68		2.66	PM R2 / PM2.5 R5
	11:00	Normal	53	88	171	25	57		2.39	NOx & CO R6
	11:30	Normal	23	38	174	0	11		1.04	
	12:00	Normal	43	72	170	16	15		1.94	
	12:30	Normal	43	72	170	16	15		1.94	PM R3 / PM2.5 R6
	13:00	Normal	60	100	166	30	70		2.70	
	13:30	Normal	39	65	174	14	30	6104	1.76	
	14:00	High	60	100	170	30	70		2.70	PM2.5 R2 / PM R4
	14:20	High	60	100	187	30	70		2.70	
	15:00	High	60	100	187	30	70		2.70	
	15:30	High	60	100	170	30	70		2.70	
	16:00	High	60	100	167	30	70		2.70	PM2.5 R3 / PM R4
	16:30	High	60	100	165	30	70		2.70	
	17:00	High	60	100	170	30	70		2.70	
	17:30	High	60	100	170	30	70		2.70	PM R6
	18:00	High	60	100	174	30	70	4649	2.70	
	18:30	High	60	100	193	30	70		2.70	
3/29/2007	8:00	Normal	31	52	77	8	15		1.56	Form R4/PAH R4/Metals R4
	8:30	Normal	60	100	96	30	70	5864	3.02	
	9:00	Normal	60	100	137	30	70		3.02	
	9:30	Normal	60	100	137	30	70		3.02	Metals R5
	10:00	Normal	58	97	165	28	66		2.92	Form R5
	10:30	Normal	28	47	170	8	15		1.41	PAH R5
	11:00	Normal	44	73	171	18	40		2.21	Form R6
	11:30	Normal	0	0	170	0	0	6118	0.0	
	12:00	Normal	29	48	159	14	30		1.68	
	12:30	Normal	60	100	158	30	70		3.02	
	13:00	Normal	39	65	172	14	30		1.96	PAH R6 / Metals R6
	13:30	Normal	0	0	171	0	0		0.0	
	14:00	Normal	42	70	165	16	36	6478	2.11	Metals R7
	14:30	Normal	39	65	172	14	30		1.96	
	15:00	Normal	6	10	166	10	15		0.30	

Notes:

lb/hr	Pounds per Hour
mmBtu/hr	Million British Thermal Units per Hour Based on Average of Fuel Analysis for the Day
Form	Formaldehyde
PAH	Polynuclear Aromatic Hydrocarbons
PM & PM2.5	Particulate Matter and Particulate Matter under 2.5 microns
NOx & CO	Nitrogen Oxides and Carbon Monoxide
R1, R2, etc..	Run 1, Run 2, etc..

3.2 PARTICULATE MATTER AND $PM_{2.5}$

Six 60-minute PM emission test runs were conducted at the boiler stack. The PM tests were conducted according to procedures outline in Environmental Protection Agency (EPA) method 5 and method 202.

Three PM test runs were performed during high fire and three PM test runs were performed during normal fire conditions. Total PM results include front half filter and probe rinse weights and back half impinger weights. The back half impinger weight is considered condensable PM (CPM) and is made up of organic and inorganic fractions. Table 3-3 and 3-4 presents the PM, CPM, and total (PM+CPM) test data obtained from the boiler stack test during high fire and normal fire conditions.

TABLE 3-3
SUMMARY OF PARTICULATE MATTER RESULTS
HIGH FIRE CONDITION
MARCH 28, 2007
COUNCIL, IDAHO SCHOOL

Parameters	Run 4	Run 5	Run 6	Average
Sample Volume (dscf)	30.51	29.88	24.20	NA
Isokinetics (%)	107	103	103	NA
Flow Rate (dscfm)	627	641	516	595
PM (lb/hr)	1.812	0.795	0.708	1.105
PM (lb/mmBtu)	0.670	0.294	0.262	0.409
CPM (lb/hr)	0.112	0.073	0.083	0.090
CPM (lb/mmBtu)	0.041	0.027	0.031	0.033
PM +CPM (lb/hr)	1.924	0.868	0.792	1.194
PM+CPM (lb/mmBtu)	0.711	0.321	0.293	0.442

Notes:
PM Particulate Matter (Front-Half)
CPM Condensible Particulate Matter (Back-Half)
dscfm Dry Standard Cubic Feet per Minute
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour
NA Not Applicable

Isokinetic percent criteria are 100 percent plus or minus 10 percent. At 100 percent isokinetics the sample velocity drawn through the probe nozzle is equal to the sample velocity of the stack. At 100 plus or minus 10 percent isokinetics, the particulate captured in the sampling system (probe, filter, and impingers) is representative of the particulates exiting the stack.

TABLE 3-4
SUMMARY OF PARTICULATE MATTER RESULTS
NORMAL FIRE CONDITION
MARCH 28, 2007
COUNCIL, IDAHO SCHOOL

Parameters	Run 1	Run 2	Run 3	Average
Sample Volume (dscf)	27.78	27.50	24.42	NA
Isokinetics (%)	104	103	110	NA
Flow Rate (dscfm)	588	584	489	554
PM (lb/hr)	0.653	0.545	1.345	0.849
PM (lb/mmBtu)	0.298	0.219	1.061	0.526
CPM (lb/hr)	0.056	0.050	0.111	0.702
CPM (lb/mmBtu)	0.026	0.020	0.087	0.044
PM +CPM (lb/hr)	0.709	0.595	1.459	0.921
PM+CPM (lb/mmBtu)	0.324	0.239	1.148	0.570

Notes:

PM	Particulate Matter (Front-Half)
CPM	Condensable Particulate Matter (Back-Half)
dscfm	Dry Standard Cubic Feet per Minute
lb/mmBtu	Pounds per Million British Thermal Units
lb/hr	Pounds per Hour
NA	Not Applicable

Six 60-minute $PM_{2.5}$ emission test runs were conducted at the boiler stack. The PM tests were conducted according to procedures outlined in the EPA conditional test method (CTM) 040 and Method 202.

Three $PM_{2.5}$ test runs were performed during high fire and three $PM_{2.5}$ test runs were performed during normal fire conditions. Total $PM_{2.5}$ results include particulate weighed after the cyclone separator including the CPM in the impingers. Table 3-5 and 3-6 presents the $PM_{2.5}$ test data obtained from the boiler stack test during high fire and normal fire conditions.

$PM_{2.5}$ test run 6 is not included in the average. The boiler experienced an upset and the filter clogged after ten minutes of run time. The data is included in this report but is not part of the three run average for $PM_{2.5}$ normal fire condition.

TABLE 3-5
SUMMARY OF $PM_{2.5}$ RESULTS
HIGH FIRE CONDITION
MARCH 27 AND 28, 2007
COUNCIL, IDAHO SCHOOL

Parameters	Run 1	Run 2	Run 3	Average
D50 Cut Point	2.36	2.23	2.26	NA
Flow Rate (dscfm)	696	660	681	679
$PM_{2.5}$ (lb/hr)	0.345	0.327	0.342	0.338
$PM_{2.5}$ (lb/mmBtu)	0.140	0.121	0.126	0.129

Notes:
PM Particulate Matter (Front-Half)
dscfm Dry Standard Cubic Feet per Minute
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour
NA Not Applicable

TABLE 3-4
SUMMARY OF PARTICULATE MATTER RESULTS
NORMAL FIRE CONDITION
MARCH 28, 2007
COUNCIL, IDAHO SCHOOL

Parameters	Run 4	Run 5	Run 6[a]	Average
D50 Cut Point	2.38	2.42	2.20	NA
Flow Rate (dscfm)	687	623	500	655
$PM_{2.5}$ (lb/hr)	0.550	0.509	2.478	0.529
$PM_{2.5}$ (lb/mmBtu)	0.251	0.204	1.950	0.228

Notes:
a Test ran for 10 minutes Due to Filter Plugging, Data Not Used in Average
PM Particulate Matter (Front-Half)
dscfm Dry Standard Cubic Feet per Minute
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour
NA Not Applicable

The D50 cut point represents the aerodynamic diameter of a particle having a 50 percent probability of passing through the cyclone. An ideal test would result in a D50 of 2.5. $PM_{2.5}$ particles are so small that the particles behave similar to a gas when entrained in the stack emissions. Therefore, isokinetic sampling is less important than with PM testing. Sampling to obtain the D50 cut point is more critical than sampling for 100 percent isokinetics.

PM and $PM_{2.5}$ field data sheets, spreadsheets, and analytical data are presented in Appendix C. Sample calculations are presented in Appendix H.

3.3 NITROGEN OXIDES, CARBON MONOXIDE, AND DILUTANT GASES

Six 60-minute NO_x, CO, O_2, and CO_2 emission test runs were conducted at the boiler stack. The NO_x, CO, O_2, and CO_2 tests were conducted according to procedures outlined in EPA methods 7E, 10, and 3A.

The NO_x, CO, O_2, and CO_2 runs were conducted on the boiler stack on April 27 and 28, 2007. Three test runs were performed during high fire condition and three test runs were performed during normal fire conditions. Table 3-7 and Table 3-8 presents the gaseous test data obtained from the boiler stack test during the high fire and normal fire emissions testing.

TABLE 3-7
SUMMARY OF GASEOUS EMISSION RESULTS
HIGH FIRE CONDITION
APRIL 27, 2007
COUNCIL, IDAHO SCHOOL

Parameters	Units	Run 1	Run 2	Run 3	Average
NO_x	**lb/hr**	0.94	1.05	1.04	1.01
	lb/mmBtu	0.38	0.43	0.42	0.41
CO	**lb/hr**	0.09	0.11	0.12	0.11
	lb/mmBtu	0.04	0.05	0.05	0.04
O_2	**%**	6.7	6.7	6.8	6.7
CO_2	**%**	13.3	13.3	13.1	13.2

Notes:
NOx Nitrogen Oxides
CO Carbon Monoxide
O_2 Oxygen
CO_2 Carbon Dioxide
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour

TABLE 3-8
SUMMARY OF GASEOUS EMISSION RESULTS
NORMAL FIRE CONDITION
APRIL 28, 2007
COUNCIL, IDAHO SCHOOL

Parameters	Units	Run 4	Run 5	Run 6	Average
NO_x	**lb/hr**	0.36	0.43	0.43	0.41
	lb/mmBtu	0.17	0.17	0.34	0.22
CO	**lb/hr**	0.05	0.12	0.09	0.09
	lb/mmBtu	0.02	0.05	0.07	0.05
O_2	**%**	11.2	9.5	8.4	9.7
CO_2	**%**	9.2	10.9	11.7	10.6

Notes:

NOx	Nitrogen Oxides
CO	Carbon Monoxide
O_2	Oxygen
CO_2	Carbon Dioxide
lb/mmBtu	Pounds per Million British Thermal Units
lb/hr	Pounds per Hour

Field data sheets, spreadsheets, and analytical data are presented in Appendix D. Sample calculations are presented in Appendix H.

3.4 METALS

Six 60-minute arsenic, cadmium, chromium, and nickel metals emission test runs were conducted at the boiler stack. The metals tests were conducted according to procedures outlined in EPA method 29.

The metals runs were conducted on the boiler stack on April 27 and 29, 2007. Three test runs were performed during high fire condition and three test runs were performed during normal fire conditions. Table 3-9 and Table 3-10 presents the metals test data obtained from the boiler stack test during the high fire and normal fire emissions testing.

TABLE 3-9
SUMMARY OF METALS EMISSION RESULTS
HIGH FIRE CONDITION
APRIL 27, 2007
COUNCIL, IDAHO SCHOOL

Analyte	Units	Run 1	Run 2	Run 3	Average
Arsenic	**(lb/hr)**	2.24e-5	1.53e-5	1.70e-5	1.82e-5
	(lb/mmBtu)	9.10e-6	6.21e-6	6.91e-6	7.41e-6
Cadmium	**(lb/hr)**	6.88e-5	1.91e-4	1.00e-4	1.20e-4
	(lb/mmBtu)	2.80e-5	7.76e-5	4.07e-5	4.88e-5
Chromium	**(lb/hr)**	9.53e-5	1.98e-4	9.34e-5	1.29e-4
	(lb/mmBtu)	3.87e-5	8.05e-5	3.80e-5	5.24e-5
Nickel	**(lb/hr)**	6.63e-5	2.02e-4	9.39e-5	1.21e-4
	(lb/mmBtu)	2.69e-5	8.23e-5	3.82e-5	4.91e-5

Notes:
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour

TABLE 3-10
SUMMARY OF METALS EMISSION RESULTS
NORMAL FIRE CONDITION
APRIL 29, 2007
COUNCIL, IDAHO SCHOOL

Analyte	Units	Run 5	Run 6	Run 7	Average
Arsenic	**(lb/hr)**	0	0	6.12e-6	2.04e-6
	(lb/mmBtu)	0	0	5.07e-6	1.69e-6
Cadmium	**(lb/hr)**	4.31e-5	9.55e-6	1.59e-5	2.28e-5
	(lb/mmBtu)	1.76e-5	5.75e-6	1.32e-5	1.22e-5
Chromium	**(lb/hr)**	3.78e-5	8.96e-6	1.80e-5	2.16e-5
	(lb/mmBtu)	1.54e-5	5.40e-6	1.49e-5	1.19e-5
Nickel	**(lb/hr)**	3.90e-5	1.02e-5	1.56e-5	2.16e-5
	(lb/mmBtu)	1.60e-5	6.12e-6	1.29e-5	1.17e-5

Notes:
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour

Test run 4 failed the leak check at the conclusion of the run and was not analyzed. An extra test run was performed in order to have three valid runs during normal fire conditions. Metals field data sheets, spreadsheets, and laboratory data are presented in Appendix E. Sample calculations are presented in Appendix H.

3.5 POLYNUCLEAR AROMATIC HYDROCARBONS (PAH)

Six 60-minute PAH emission test runs were conducted at the boiler stack. The PAH tests were two hour in duration and were conducted according to procedures outlined in EPA method 0010.

The PAH runs were conducted on the boiler stack on April 27 and 29, 2007. Three test runs were performed during high fire condition and three test runs were performed during normal fire conditions. Table 3-11 and Table 3-12 presents the PAH test data obtained from the boiler stack test during the high fire and normal fire emissions testing. PAH field data sheets, spreadsheets, and laboratory data are presented in Appendix E. Sample calculations are presented in Appendix H.

TABLE 3-11
SUMMARY OF PAH EMISSION RESULTS
HIGH FIRE CONDITION
APRIL 27, 2007
COUNCIL, IDAHO SCHOOL

Analyte	Units	Run 1	Run 2	Run 3	Average
Acenaphthene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Acenaphthylene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Anthracene,	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benz(a)anthracene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benzo(b)fluoranthene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benzo(k)fluoranthene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benzo(ghi)perylene	(lb/hr)	3.72e-6	0	0	1.24e-6
	(lb/mmBtu)	1.51e-6	0	0	5.04e-7
Bezo(e)pyrene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benzo(a)pyrene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Chrysene,	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Dibenz(a,h)anthracene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Fluoranthene,	(lb/hr)	1.93e-5	0	0	6.43e-6
	(lb/mmBtu)	7.85e-6	0	0	2.62e-6
Fluorene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Indeno(1,2,3-cd)pyrene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
2-methylnaphthalene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Naphthalene	(lb/hr)	1.93e-5	5.49e-6	3.25e-6	9.35e-6
	(lb/mmBtu)	7.85e-6	2.23e-6	1.32e-6	3.80e-6
Phenanthrene	(lb/hr)	1.79e-5	0	0	5.97e-6
	(lb/mmBtu)	7.29e-6	0	0	2.43e-6
Pyrene	(lb/hr)	2.21e-5	0	0	7.35e-6
	(lb/mmBtu)	8.97e-6	0	0	2.99e-6

Notes:
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour

TABLE 3-12
SUMMARY OF PAH EMISSION RESULTS
NORMAL FIRE CONDITION
APRIL 29, 2007
COUNCIL, IDAHO SCHOOL

Analyte	Units	Run 1	Run 2	Run 3	Average
Aacenaphthene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Acenaphthylene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Anthracene,	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benz(a)anthracene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benzo(b)fluoranthene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benzo(k)fluoranthene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benzo(ghi)perylene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Bezo(e)pyrene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Benzo(a)pyrene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Chrysene,	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Dibenz(a,h)anthracene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Fluoranthene,	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Fluorene	(lb/hr)	7.80e-6	5.41e-6	0	4.40e-6
	(lb/mmBtu)	2.97e-6	5.60e-6	0	2.86e-6
Indeno(1,2,3-cd)pyrene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
2-methylnaphthalene	(lb/hr)	0	0	0	0
	(lb/mmBtu)	0	0	0	0
Naphthalene	(lb/hr)	1.80e-5	1.11e-5	6.34e-6	1.18e-5
	(lb/mmBtu)	6.86e-6	1.15e-5	9.55e-6	9.30e-6
Phenanthrene	(lb/hr)	1.16e-5	7.07e-6	0	6.21e-6
	(lb/mmBtu)	4.40e-6	7.32e-6	0	3.91e-6
Pyrene	(lb/hr)	8.85e-6	1.52e-5	0	8.03e-6
	(lb/mmBtu)	3.37e-6	1.58e-5	0	6.39e-6

Notes:
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour

3.6 FORMALDEHYDE

Six 60-minute formaldehyde emission test runs were conducted at the boiler stack. The formaldehyde tests were conducted according to procedures outlined in EPA method 323.

The formaldehyde runs were conducted on the boiler stack on April 27 and 29, 2007. Three test runs were performed during high fire condition and three test runs were performed during normal fire conditions. Table 3-13 and Table 3-14 presents the formaldehyde test data obtained from the boiler stack test during the high fire and normal fire emissions testing. Formaldehyde field data sheets, spreadsheets, and laboratory data are presented in Appendix E. Sample calculations are presented in Appendix H.

TABLE 3-13
SUMMARY OF FORMALDEHYDE EMISSION RESULTS
HIGH FIRE CONDITION
APRIL 27, 2007
COUNCIL, IDAHO SCHOOL

Analyte	Units	Run 1	Run 2	Run 3	Average
Formaldehyde	**(lb/hr)**	0.0029	0.0019	0.0022	0.0023
	(lb/mmBtu)	0.0012	0.0008	0.0009	0.0009

Notes:
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour

TABLE 3-14
SUMMARY OF FORMALDEHYDE EMISSION RESULTS
NORMAL FIRE CONDITION
APRIL 29, 2007
COUNCIL, IDAHO SCHOOL

Analyte	Units	Run 5	Run 6	Run 7	Average
Formaldehyde	**(lb/hr)**	0.0021	0.0028	0.0020	0.0023
	(lb/mmBtu)	0.0008	0.0013	0.0009	0.0010

Notes:
lb/mmBtu Pounds per Million British Thermal Units
lb/hr Pounds per Hour

4.0 METHODS AND CALCULATIONS

All emissions testing were performed in accordance with Environmental Protection Agency (EPA) methods as described in Title 40 of the Code of Federal Regulation (CFR). The specific methods employed during the test campaign are listed below.

<u>METHOD 1 – “Sample and Velocity Traverses For Stationary Sources”</u>

Appropriate sampling point locations were determined using method 1 procedures. Stack dimensions, number of ports, and number of traverse points for testing were determined the first day of the test. Figure 4-1 shows the stack dimensions measured on the day of testing. Based on stack dimensional measurements, 8 sampling points were required (4 points per port) for accurate flow and isokinetic sampling. Table 4-1 provides the traverse point locations for each port on the boiler stack.

FIGURE 4-1
STACK DIMENTIONS

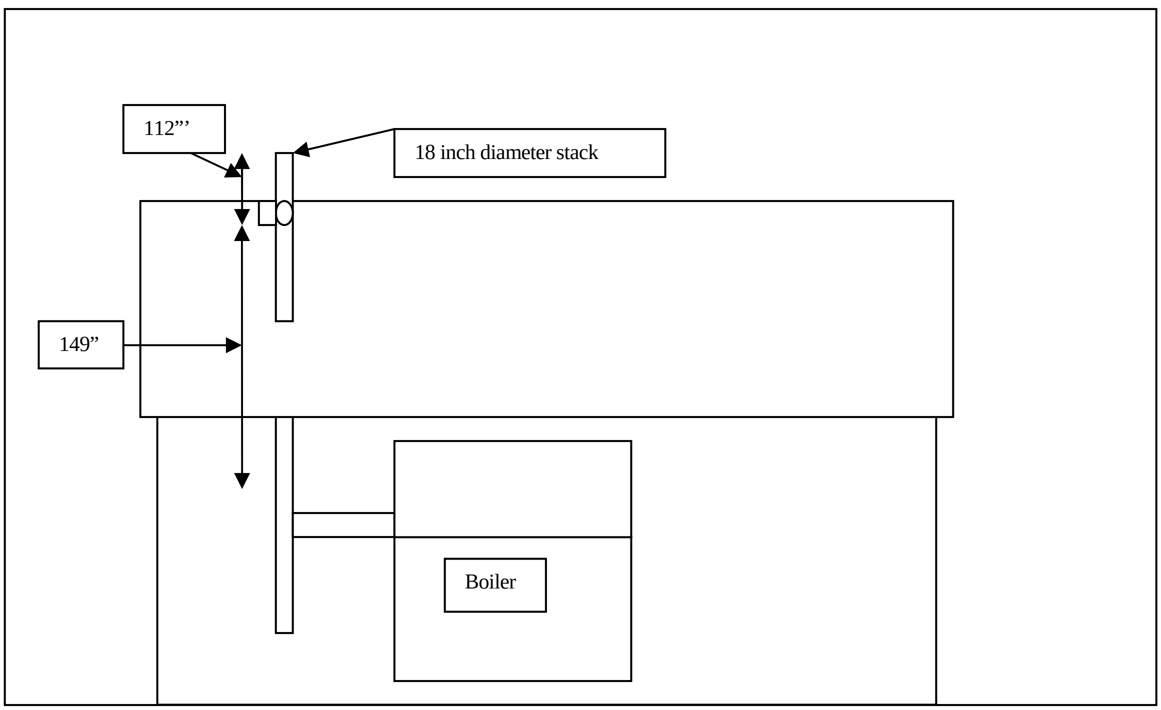


TABLE 4-1
TRAVERSE POINT LOCATIONS

Point Number	Distance From Stack Wall (inches)	Port Length (inches)	Total Distance (inches)
1	1.2	4.5	5.7
2	4.5		9.0
3	13.5		18.0
4	16.8		21.3

METHOD 2 – "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)"

Method 2 was included in the method 5, 29, and 0010 tests.

METHOD 3A – "Gas Analysis for the Determination of Dry Molecular Weight (Instrumental Analyzer Method)"

Three method 3A tests were performed simultaneously with the NO_x and CO emission tests on the boiler. The molecular weight was determined by measuring the oxygen (O_2) and carbon dioxide (CO_2) percentages in the boiler exhaust. The method assumes that nitrogen (N_2) is also present in the exhaust stream and the difference of the O_2 and CO_2 subtracted from 100 is equal to the percentage of nitrogen. The dry molecular weight (M_d) is calculated by the following formula.

$$M_d = (0.440)(\%CO_2) + (0.320)(\%\ O_2) + (0.280)(\%N_2 + \%CO)$$

Percentages of CO measured in the inlet and outlet stack were too low to be of significance in this equation.

A Servomex model 1400 analyzer measured the O_2 and CO_2 concentrations. This analyzer measures O_2 using paramagnetic technology, and measures CO_2 using infrared technology. The sampling system consisted of a probe, heated filter, heated sample line, condenser, pump, and sample manifold. Figure 4-4 shows a schematic of the O_2 and CO_2 sampling system

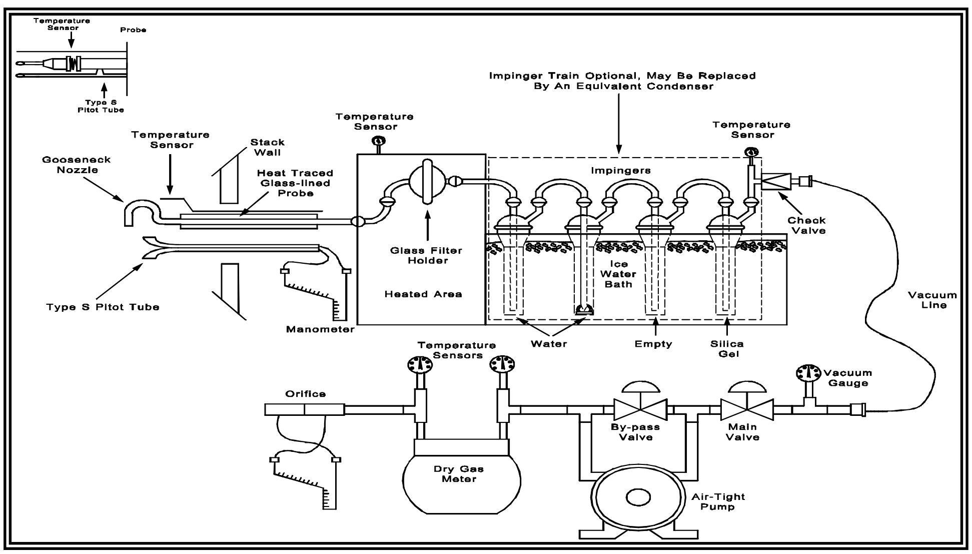
METHOD 4 – “Determination of Moisture Content in Stack Gases”

Method 4 was included in the method 5, 29, 0010, and 323 tests.

METHOD 5 – “Determination Of Particulate Emissions From Stationary Sources”

Six method 5 test runs were performed. Figure 4-2 is a diagram of the sample train system used in testing the boiler on March 28, 2007 for PM.

FIGURE 4-2
METHOD 5 PM SAMPLE TRAIN DIAGRAM

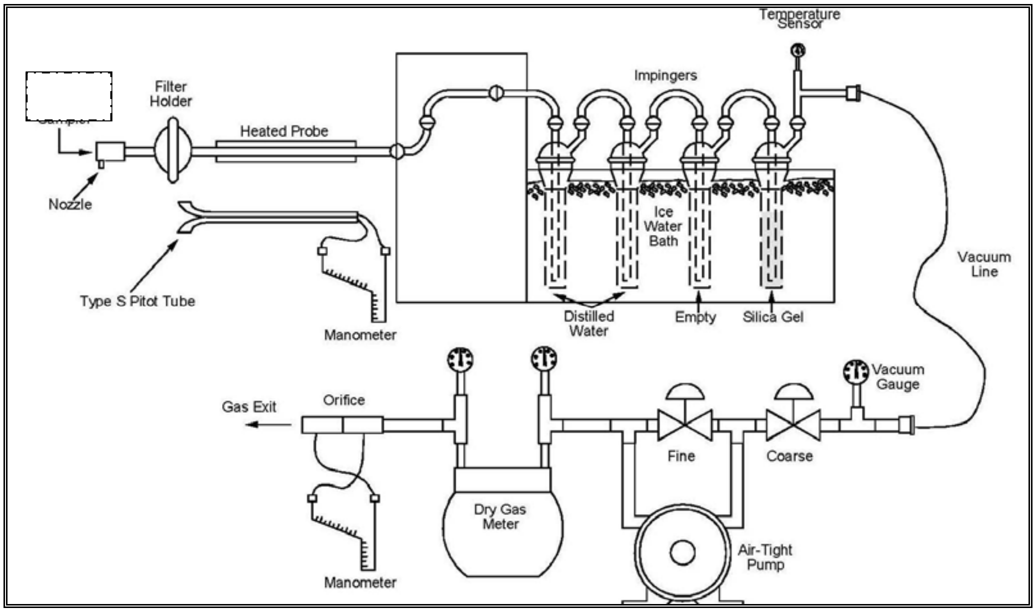


CTM 040 – “Determination Of $PM_{2.5}$ Emissions (Constant Sampling Rate Procedure)”

Six CTM 040 test runs were performed on the boiler. Figure 4-3 is a diagram of the sample train system used in testing the boiler on March 27, and 28, 2007 for $PM_{2.5}$.

CTM 40 method combines PM_{10}, and $PM_{2.5}$ cyclones together in order to obtain information for both PM sizes. Aspen modified this method to test $PM_{2.5}$ only. PM_{10} and $PM_{2.5}$ could not be tested for simultaneously due to physical restraints of the sample ports.

FIGURE 4-3
CTM 040 $PM_{2.5}$ SAMPLE TRAIN DIAGRAM



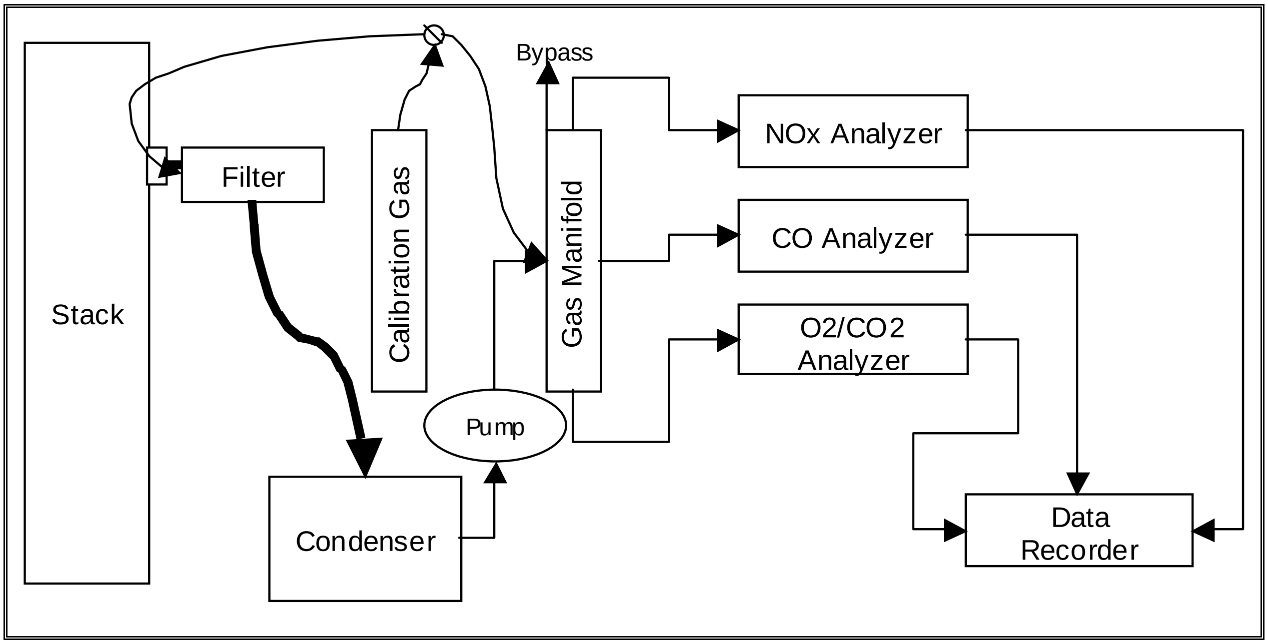
METHOD 7E – Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrumental Analyzer Procedure)

Six 60-minute method 7E test runs were performed on the boiler stack. The NO_x analyzer used was a Thermo Environmental (TECO) Model 42C. The analyzer range was set to 1200 parts per million (ppm). The analyzer system response time was measured to be 45 seconds. Figure 4-4 shows a schematic of the sample train used for the Method 7E tests.

METHOD 10 – Determination of Carbon Monoxide Emissions from Stationary Sources

Six 60-minute method 10 test runs were performed on the boiler stack. The CO analyzer used was a TECO Model 48C. The analyzer range was set to 1200 ppm. Figure 4-4 shows a schematic of the sample train used for the Method 10 tests. The analyzer system response time was measured to be 40 seconds.

FIGURE 4-4
METHODS 7E, 10, AND 3A SAMPLE TRAIN SCHEMATIC

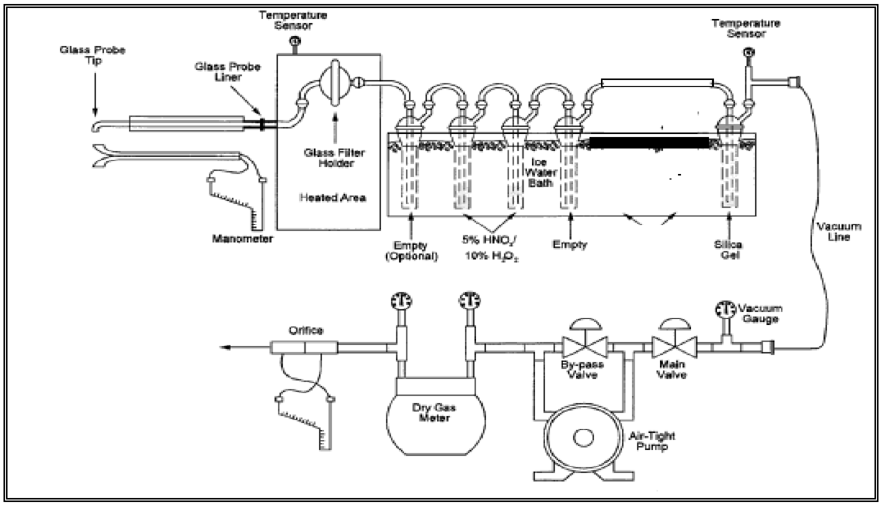


<u>METHOD 29 – "Determination of Metals Emissions From Stationary Sources"</u>

Seven method 29 test runs were performed. Figure 4-5 is a diagram of the sample train system used in testing the boiler on March 27 and 29, 2007 for arsenic, cadmium, chromium, and nickel.

Seven method 29 tests were performed on the boiler, three test runs during high fire condition and four test runs during normal fire conditions. Of the four test runs performed on the boiler under normal fire conditions, test run 4 was discarded. Test run 4 was the first run under normal fire and was discarded due to a final leak check failure. Apparently, the glass probe line broke sometime during the test run. A seventh test was performed in order to have a total of three valid test runs during the normal fire conditions.

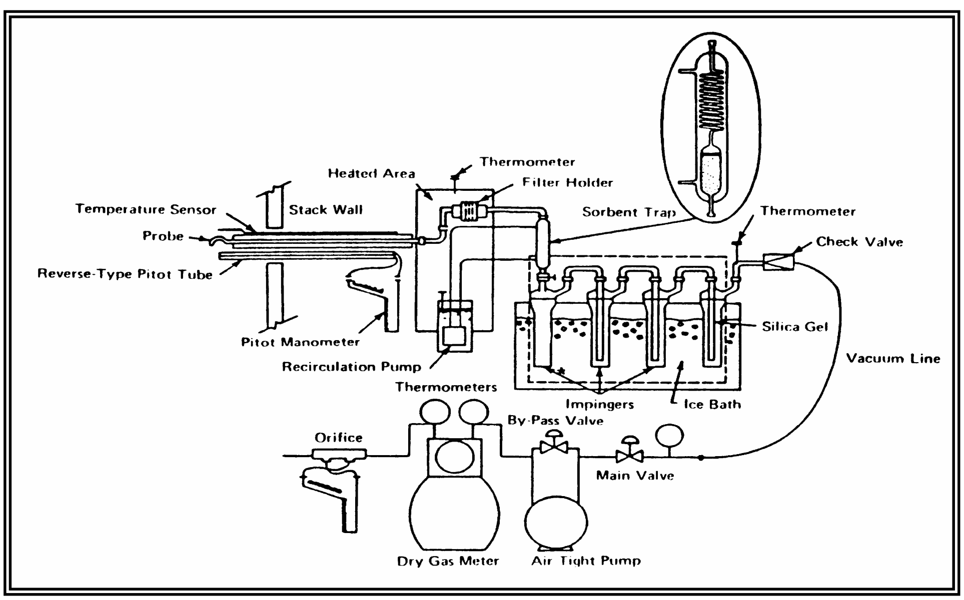
FIGURE 4-5
METHOD 29 METALS SAMPLE TRAIN DIAGRAM



METHOD 0010 – "Determination of PAH Emissions From Stationary Sources"

Six method 0010 PAH test runs, three at high fire and three at normal fire conditions were performed. Figure 4-6 is a diagram of the sample train system used in testing the boiler on March 27 and 29, 2007.

FIGURE 4-6
METHOD 0010 PAH SAMPLE TRAIN DIAGRAM

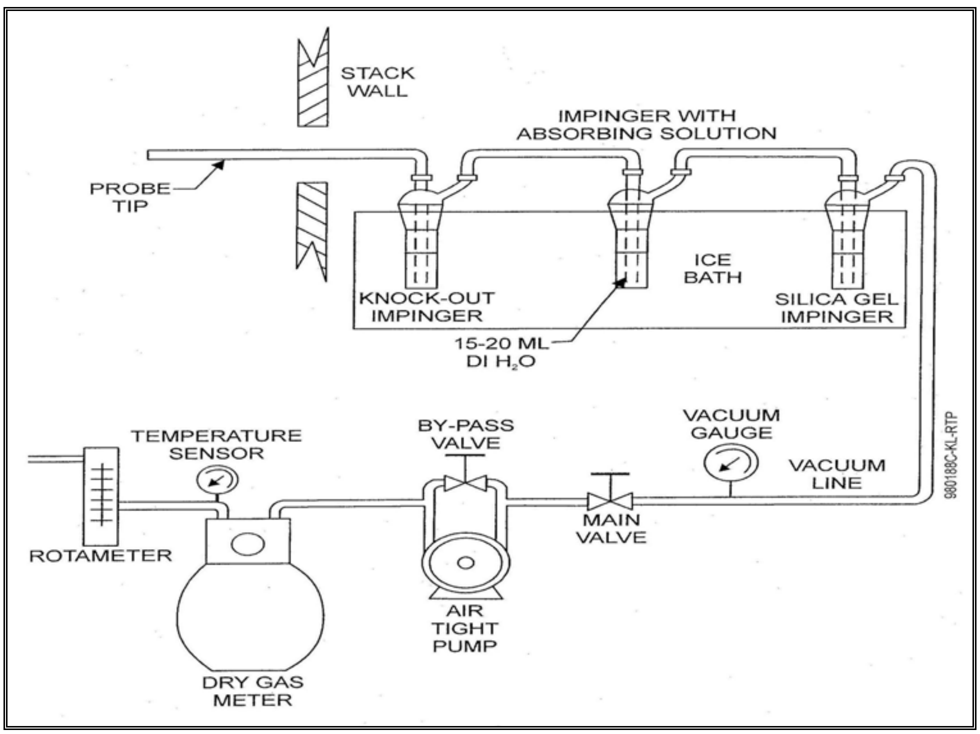


METHOD 323 – "Determination of Formaldehyde Emissions From Natural Gas Fired Stationary Sources"

Six method 323 formaldehyde test runs, three at high fire and three at normal fire conditions were performed. Figure 4-7 is a diagram of the sample train system used in testing the boiler on March 27 and 29, 2007.

A modification to this method is to replace the midget impingers with larger method 5 impingers. The sample volume is greatly increased which yields a lower detection limit. A 44 milliliter aliquot sample was recovered from the impingers and analyzed for formaldehyde. A spike and duplicate analysis was performed by Northern Analytical Laboratory. Aspen did not perform a duplicate or spiked test run.

FIGURE 4-7
METHOD 323 FORMALDEHYDE SAMPLE TRAIN DIAGRAM



5.0 QUALITY ASSURANCE

All emissions testing equipment was pre-calibrated and post-calibrated in accordance with test and manufacturer method specifications. Calibration documentation for the meter box, pitot tubes, nozzles, probes, and calibration gas certifications are included in Appendix I.

Leak checks of the sampling trains were performed before and after each test run. Leak checks verify that the gas collected across the filter and through the impingers are from the stack and not from ambient air due to leaks in the sampling system. The amount of acceptable leak, according to Method 5, is 0.02 cubic feet per minute at the highest tested vacuum. One leak check failed on the metals test run 4. This test was thrown out and a test run 7 was performed in order to obtain three valid test runs during the normal fire condition